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A PROCESS FOR ASSESSING THE IMPACT OF DREDGING PROJECTS ON THE BIOLOGICAL RESOURCES OF THE BEAUFORT SEA

BY
L.C. MARTIN, W.S. DUVAL
AND D.J. THOMAS

W & NR 86/87 -CP(EP)-7

Environmental Protection Service

Service de la protection de l'environnement

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ABSTRACT

This report outlines a process for assessing the impacts of dredging projects in a semi-quantitative and consistent manner. The process was developed and refined in workshops with potential users and incorporates standardization of assessment procedures through the use of consistent defined terminology, the application of consistent criteria for assessments, and the use of an "audit trail" which can be subjected to subsequent peer review. Following a presentation and explanation of the process, the results of its application in two case studies are presented. The case studies assess the anticipated impact from deepening a dock area in Tuktoyaktuk Harbour, and the impact of dredging to install a subsea pipeline from a Nipterk wellsite to Richards Island. It is expected that application of this assessment process will prove to be a useful means of resolving conflicts related to the approval of dredging projects.

RÉSUMÉ

Dans le présent rapport, on décrit un processus devant servir à assurer une évaluation semi-quantitative et uniforme des repercussions des projets de dragage. Ce processus a été élaboré et perfectionné lors d'ateliers tenus avec des utilisateurs potentiels. L'uniformité de l'évaluation est assurée par la définition des termes employés, l'application de critères uniformes et l'utilisation d'un "mode de vérification" pouvant être soumis à un examen par des collegues. Après une présentation et une explication du processus, les résultats de son emploi dans deux études de cas sont présentés. Les cas étudiés sont le dragage d'une partie du port de Tuktoyaktuk et du tracé d'un pipeline sous marin devant relier le chantier de forage de Nipterk à l'île Richards. L'application du processus décrit devrait s'avérer un moyen utile de résoudre les conflits relatifs à l'approbation des projets de dragage.

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1.0 INTRODUCTION

ESL in association with B. Smiley (Institute of Ocean Sciences, Fisheries and Oceans Canada) developed a semi-quantitative method for preliminary assessment of environmental impact (Duval et al. 1984) to address three fundamental concepts important to both the preparation and review of impact assessments. These three concepts are:

1) the standardization of assessment procedures through the use of consistent defined terminology;

2) the application of consistent criteria for assessments; and

3) encouragement of assessors to provide an "audit trail" for subsequent peer review (e.g., rationale, references, evidence, calculations of zones of influence, and reliability and applicability of data used or cited).

This method has been modified and adapted to provide the Environmental Protection Service with a Process for Assessing the Impact of Dredging Projects on the Biological Resources of the Beaufort Sea. The process is particularly useful for resolving conflicts related to dredging program approvals and with appropriate modifications could be applied to dredging projects elsewhere in Canada. Modification of the Duval et al. (1984) assessment procedure was completed in two stages: first ESL and biologists from the Freshwater Institute (DFO) in Winnipeg completed two hypothetical dredging application assessments to revise the methodology, and then the revised procedure was refined and finalized at a two-day workshop held in Vancouver, and attended by government and industry representatives. A list of the participants that attended the workshop and contributed to the final process presented in this report is included in Appendix I.

The process has been designed as a tool for evaluation of those Applications to Dredge or Dump Spoil that, at a preliminary stage of assessment, are considered by any reviewer to pose significant biological

concerns. It provides a standard systematic approach to determine the relative degree of significance of potential biological effects. Consistent evaluation criteria and terminology are applied to selected populations of Valued Ecosystem Components (VECs) and their habitats to derive a ranked class of environmental significance between 1 and 4, with a Class 1 rating representing the greatest degree of concern. The process incorporates the regulatory requirements of the Ocean Dumping Control Act (ODCA), Public Lands Grants Act (PLGA) and Navigable Waters Protection Act (NWPA) and may, in conjunction with other guidelines, be used for assessing the effects of both dredging and dumping.

This report is intended as a guide to the process but also contains: (1) background information regarding the concepts involved in the method (Section 2.0); and (2) two hypothetical case studies to illustrate application of the process (Section 4.0). Section 3.0 provides detailed step-by-step instructions for use of the method, as well as examples of Tables that are used at each stage of the assessment. A working set of blank Tables is also provided in the pocket on the back cover of the report.

2.0 BACKGROUND CONCEPTS FOR THE ASSESSMENT PROCESS

This section briefly describes some of the important background concepts appplied during each step in the process. A glossary of some terms used in this report is included in Appendix II.

The nine steps that comprise this process for assessment of dredging applications are shown in Figure 1. The first two steps are completed for every application and include:

1. collection and review of details concerning the project (e.g., schedule, type of dredge, location of project, type of substrate, etc.); and

2. application of Ocean Dumping Control Act (ODCA), Public Lands Grants Act (PLGA), Navigable Waters Protection Act (NWPA) and, if necessary, other guidelines.

Steps 3 to 9 are completed only if significant environmental concerns are identified during Step 2. Steps 3 to 5 are completed once and include:

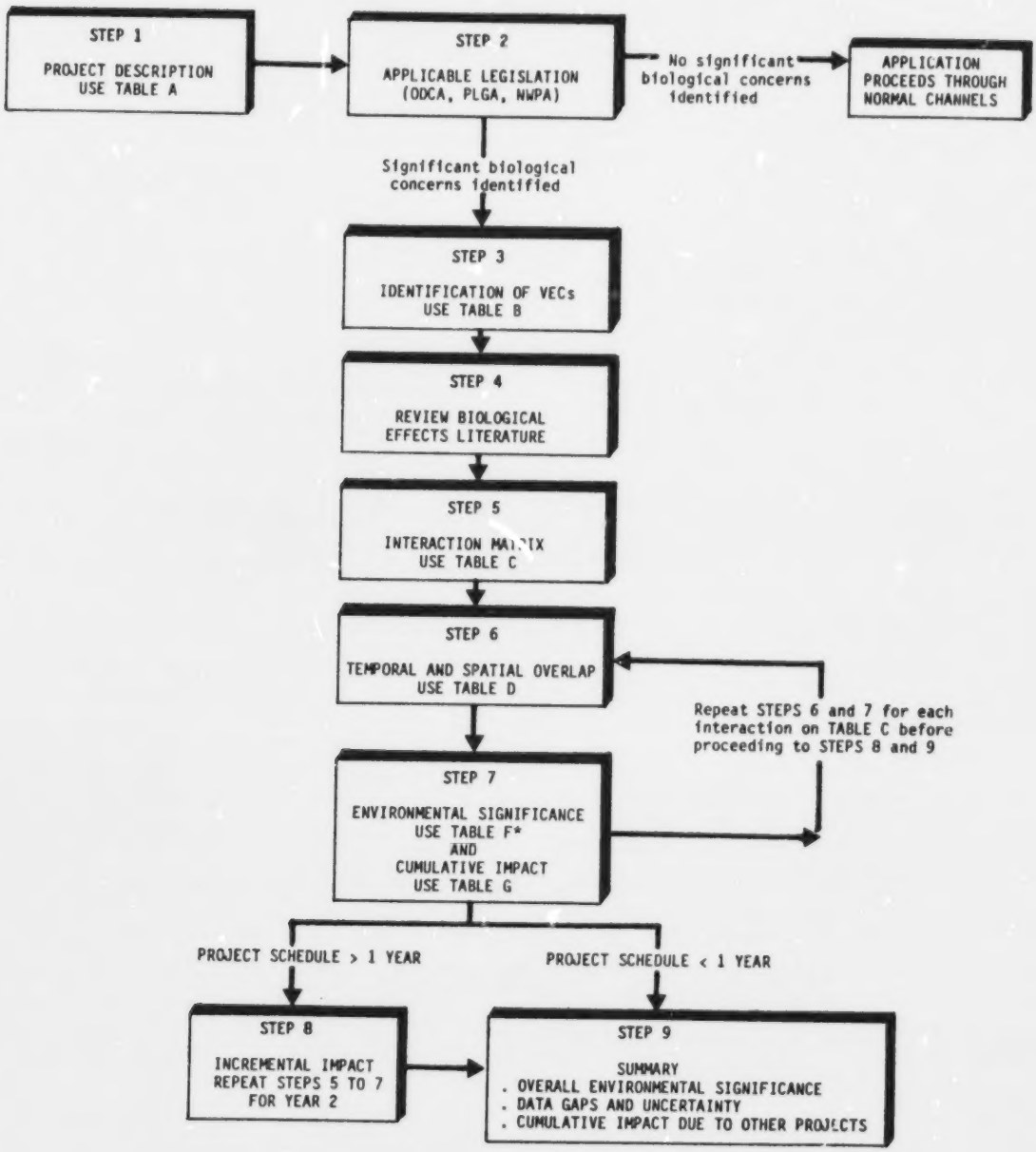
3. identification of important populations and their habitats using pre-defined social, economic and environmental criteria that determine Valued Ecosystem Components (VECs);

4. collection and review of relevant literature concerning the biological effects of dredging and dumping spoil on VEC populations and habitats of the Beaufort Sea; and

5. preparation of a simple matrix that delineates all potential interactions between selected VECs and dredging disturbances.

FIGURE 1

NINE STEPS FOR ASSESSMENT OF THE IMPACT OF DREDGING PROJECTS ON THE BIOLOGICAL RESOURCES OF THE BEAUFORT SEA



* NOTE: Tables E and H are used for Audit Trail in Steps 5 to 8.

Steps 6 and 7 are repeated for each interaction and include:

6. prediction of the degrees of overlap, in time and space, between the VEC population and each project disturbance; and

7. assessment of the annual environmental significance of each disturbance-VEC interaction (based on criteria involving survival, reproduction and recovery potential) and the potential for cumulative impact due to various project disturbances simultaneously affecting VECs.

Step 8 is completed only for projects with a duration that exceeds one year:

8. consideration of the possible incremental impact of long-term disturbance-VEC interactions, particularly those that may be additive or multiplicative.

The final step in the process is:

9. preparation of a brief summary that discusses (1) the overall environmental significance of the project, (2) important data gaps, (3) certainty regarding ranking of environmental significance, and (4) the potential for cumulative impact due to other projects in the region or other stresses on VEC populations or their habitat.

The assessor is encouraged to compile an audit trail throughout the process of determining temporal and spatial overlap, as well as during the assessment of environmental significance. This record of rationales, assumptions and calculations permits review and scrutiny of the assessment by other regulatory agencies, proponents, scientists, other individuals involved in dredging application review and the public. The audit trail also includes a judgement on information quality. This relative ranking of the information

used during the application review as good, poor or unknown is intended to clearly identify for both the assessor and reviewer those aspects of the process where data gaps may have affected the certainty of the assessment.

To focus the assessment on populations of greatest ecological, economic or social concern, the Valued Ecosystem Component (VEC) concept of Beanlands and Duinker (1983) is used. A VEC may be chosen on the basis of perceived public concerns related to social, cultural, recreational, aesthetic or economic significance. They may also be chosen to reflect scientific concerns, trophic importance, rare or international status, or their vulnerability or sensitivity to dredging-related disturbances. These criteria for selection of VECs are defined in Appendix II.

The population level of biological organization is the basic working unit of the assessment process because of its self-regulating nature, and the fact that each population is characterized by:

- birth and death rates;
- a growth form;
- age structure;
- density; and
- a seasonal pattern of abundance and distribution over a geographic range or habitat.

These characteristics are measureable, and they should together, reflect most types and degrees of potential harm or adverse change caused by man's activities.

These VEC populations will generally include the "high profile" resources of the region, usually fish, mammal and bird species. However, invertebrates (e.g., shellfish) and plants (e.g., kelp) can qualify as VECs. The prey of Valued Ecosystem Components (e.g., phytoplankton) are seldom VECs, but can be addressed as essential habitat of a VEC.

The inclusion of habitat in the assessment procedure is necessary because of the indirect impact that dredging may have on VEC populations. Unlike direct effects, which can only occur at the time of a project activity, indirect effects on populations can be caused both during and after the project activity if long-term damage to important habitats has occurred. If the project interaction persists over several years, such long-term and indirect impact can be of greater importance than short-term direct effects to the survival and reproduction of populations .

A major requirement of this process is to distinguish between: (1) the temporal and spatial overlap of VEC populations and habitats with project disturbances; and (2) the environmental significance of possible biological effects. A single year is used as the base period for the assessment of temporal overlap. If the project is scheduled to occur during more than one year, the assessment process should be completed separately for each year to determine annual differences in the overlap of VEC populations and habitats with project disturbances. Predicting spatial overlap requires the determination of the zone of influence of each project disturbance in relation to the boundaries of both the population distribution and available habitat in the region. This is important because a population may be confined to a small portion of its range during certain periods of the year. In addition, the type of habitat should be considered. For example, some populations may use several habitat types within the same region (e.g., overwintering sites, migration corridors, staging areas, spawning grounds) that overlap to varying degrees with the project's zones of influence.

Two categories (less than 10 percent and 10 to 100 percent) were selected to roughly describe the magnitude and duration of a VEC-versus-project interaction. The selection of ten percent as the division between these categories was arbritrary, although the authors believe that ten percent represents a proportion that would normally exceed natural variability in population levels. In some cases, there are adequate data to predict, with relative confidence, the proportion of a population that may be affected, as

well as the annual duration of that interaction. Assessors are encouraged to be as precise as practical in their determination of overlap and to record the actual percent of the population or habitat affected where adequate data are available, rather than identify a broad category of spatial and temporal overlap. However, more often a high degree of resolution is not possible given the available information and biological variability, but the degree of overlap can still be identified as either greater or less than ten percent.

3.0 DREDGING PROJECT ASSESSMENT PROCESS

3.1 Step 1: Review the Dredging Project Description

The first step in the process is to collect and review relevant information concerning the nature, timing, and magnitude of the proposed dredging project. For dredging projects permitted under the authority of the ODCA, the information should be provided on the Application for a Permit to Dump and/or to Load Dredged Material for the Purpose of Dumping [Environment Canada form 08-1009(08-75)]. For dredging permitted under the authority of the PLGA, TLA or NWPA, the information should be provided on the appropriate licence or lease application. Some additional information regarding other projects in the area and calculations regarding the area where activities will occur may be required. Information should include:

- the volume of material to be dredged;
- geographic location and area for dredging and spoil disposal or construction activity;
- physical and chemical characteristics of material to be dredged;
- nature of substrate material at the dump or construction site;
- type of dredge to be used;
- proposed schedule for project activities;
- distance and route between dredge and dump or construction sites;
- proposed mitigative measures; and
- other existing or proposed projects in the area.

With respect to mitigative measures, it is necessary to assess the impact of a project by assuming that measures described in the initial application are in place, and that they will be 100 percent effective. The assumption that mitigative measures are 100 percent effective is necessary when: (1) proponents actually describe the mitigative measures that are proposed as part of the project design; or (2) assessors determine that

mitigation is necessary after assessing the impact of a project on biological resources, and then use the process to confirm a reduced impact with the recommended mitigation in place.

Summarize project information relevant to the assessment of biological effects on Table A. Indicate the source of the information and any mitigative measures proposed.

TABLE A

PROJECT DESCRIPTION

PROJECT: _____

PROJECT SCHEDULE: _____

ASSESSOR: _____ ORGANIZATION: _____ DATE: _____

SHEET NO. ___ OF ___

PROJECT DISTURBANCE	MITIGATIVE MEASURE(S)	INFORMATION SOURCE*

* Indicate: 1-4, (1) Application, (2) Communication from Applicant, (3) Calculation or (4) Assumption (Add other categories as required.)

3.2 Step 2: Apply the Requirements of the Applicable Legislation (Ocean Dumping Control Act, Public Lands Grants Act and Navigable Waters Protection Act)

The Application is first reviewed under the authority of the appropriate legislation to assess compliance with legislated requirements. At this stage, any conflicts associated with other uses of the sea (i.e. obstruction to navigation or degradation of water quality), or sediment contamination in excess of regulated limits, are identified and resolved. If such conflicts do not exist and there are no other perceived biological concerns associated with the project, then the application can proceed through the normal channels of the review and approvals procedure. On the other hand, if there are remaining concerns regarding the effects of the project on biological resources, then the detailed assessment process outlined in the following steps is completed to evaluate the seriousness of these potential concerns.

3.3 Step 3: Identify Valued Ecosystem Components (VECs)

A list of VECs* for the southern Beaufort Sea was compiled as part of the Beaufort Environmental Monitoring Project (INAC and Environment Canada 1984) and included the population, harvest and available habitat for:

- white (beluga) whale
- bowhead whale
- ringed seal
- bearded seal
- polar bear
- common eider
- king eider
- diving ducks (oldsquaw, scoter, scaup)
- thick-billed murre
- brant
- lake whitefish
- broad whitefish
- least cisco
- arctic cisco
- arctic char

Although VECs will normally be selected from the above list, others may be considered. For the purpose of the assessment process, the impact on a specific biological resource should be evaluated if that resource is considered to be a VEC using the criteria identified in Section 2.0 and Appendix II.

Using Table B, provide a rationale for the selection of each VEC. Become familiar with the background information regarding:

- species' biology;
- distribution and abundance in the region;
- physical/chemical factors affecting its distribution;
- habitats and habitat requirements;
- the timing of major life history events;

* the definition of a VEC applied during the BEMP process was more restrictive than the one used in this process.

- food web relationships;
- harvest levels and social significance;
- existing stresses on the population; and
- natural variability and reproductive stability.

TABLE B

RATIONALE FOR SELECTION OF VALUED ECOSYSTEM COMPONENTS (VECs)

PROJECT: _____

SHEET NO. ___ OF ___

VEC Common/Scientific Names	RATIONALE FOR SELECTION

3.4 Step 4: Access and Review Biological Effects Literature

Collect and review literature that describes the effects associated with dredging on the VECs selected. Selected sources of information are listed in Appendix III.

3.5 Step 5: Prepare Project Interaction Table

Tables B and C are required for the completion of this step.

List VECs selected during Step 3 along the horizontal axis. Note that two vertical columns are allocated for each VEC: one for the population itself (indicated P), and the other for its habitat (indicated H).

Potential disturbances related to dredging and dumping activities may include:

Dredging Disturbances

- altered sediment composition
- altered bottom contours, alterations in nearshore wave and circulation patterns, altered offshore bottom current patterns, and shoreline erosion
- increased suspended sediment and turbidity levels
- suction currents with some types of dredges
- creation of underwater noise
- physical presence

Dumping Disturbances

- altered bottom contours
- increased suspended sediment and turbidity levels
- decreased dissolved oxygen levels
- resuspension of toxic chemicals
- increased nutrient concentrations
- creation of underwater noise
- alteration of vertical temperature and salinity stratification
- settling and flocculation of suspended sediment
- altered sediment composition
- physical presence

Some disturbances are common to both dredging and dumping activities, and if the project includes both activities, assessors may choose to assess a disturbance only once. It would then be important to simultaneously consider the location of the zones of influence of both the dredging and dumping related disturbance.

Select potential disturbances relevant to the project and VECs, and then list these along with the vertical axis of Table C under the heading of dredging or dumping.

TABLE C

PROJECT INTERACTION

PROJECT: _____

SHEET NO. ___ OF ___

PROJECT DISTURBANCES	VALUED ECOSYSTEM COMPONENTS											
	P*	H**	AT	P	H	AT	P	H	AT	P	H	AT
DREDGING												
DUMPING												

* - population
** - habitat
ES - environmental significance assessed
\- - no interaction
AT - Audit Trail Cross - Reference (Table E)

3.6 Step 6a: *Predict the Spatial and Temporal Overlap for Each Interaction

This step involves a prediction of the overlap of each VEC and its habitat with each project disturbance. The procedure is repeated for each interaction (box) identified in Table C and involves calculation or estimation of the degree of temporal and spatial overlap between each disturbance and VEC.

To begin Step 6a, transfer the list of VECs and project disturbances (Table C) to the first column on Table D. Write the project disturbances under each VEC heading.

The purpose of this step is to identify those project disturbances which require further assessment of environmental significance in later steps. The amount of time spent on each Interaction in Table D need not be extensive, but each one must be addressed.

To predict overlap, consider and answer four fundamental questions:

i) **Spatial Overlap with VEC Population**

What is the estimated percent of the regional VEC population that may be involved in a direct interaction with project disturbance?

ii) **Spatial Overlap with VEC Habitat**

What is the estimated percent of the species habitat that may be within the zone of influence of the project disturbance?

---

* Note: Steps 6a through 6c are to be completed concurrently.

TABLE D

SPATIAL AND TEMPORAL OVERLAP

PROJECT: _____

SHEET NO. ___ OF ___

VEC/ DISTURBANCE (List)	SPATIAL OVERLAP						TEMPORAL OVERLAP					
	POPULATION			HABITAT			POPULATION			HABITAT		
	<10p	>10p	AT	<10p	>10p	AT	<10p	>10p	AT	<10p	>10p	AT

AT = Audit Trail Cross-Reference (Table E)
p = percent

iii) **Temporal Overlap with VEC Population**

What is the percent of annual residence time of the VEC population during which direct interaction with the project disturbance may occur?

(iv) **Temporal Overlap with VEC Habitat**

What is the percent of the year during which the VEC habitat may be within the zone of influence of the project disturbance?

As indicated previously, it is possible to respond to these questions by indicating:

(1) a category of less or greater than ten percent;

(2) a more accurate estimate of the percent overlap of the population or its habitat with the disturbance; or

(3) an audit trail note for no interaction.

The calculated responses to these questions should be noted in the appropriate columns of Table D. To complete this and other steps in the assessment, it will be necessary to make several assumptions regarding the project, the VEC populations, and their habitats. Make reasonable assumptions on the basis of existing data and systematically record all assumptions (see Step 6c: Leave Audit Trail). In cases where a lack of data prevents or hampers reliable calculations, adopt a worst case or conservative approach and state where and why this was necessary.

Some other considerations

In predicting spatial overlap, simultaneously consider:

- the zone of influence of each project disturbance; it may be practical to estimate this zone as the distance where "background" conditions are achieved. Any assumptions should be documented in Step 6c; and

- the distributions and abundance of the VEC population and types and locations of its habitats in relation to the zone of influence (habitats should include all biophysical factors upon which the VEC population depends).

It may be helpful to prepare rough maps showing the spatial overlap; this allows better visualization of the area disturbed relative to the distribution and habitat of the VEC.

In predicting the temporal overlap, simultaneously consider:

- the time of year when the project disturbances may affect the VEC population or its habitats;

- the length of time that the VEC population and its prey organisms are present in the region; and

- the length of time that the VEC population or its habitats may occur within the zone of influence of the project disturbance.

Step 6a is repeated for each VEC-disturbance interaction on Table C.

Step 6b: Complete Project Interaction Table

Complete the overlap prediction for each VEC-disturbance interaction on Table D, and simultaneously fill in the corresponding box on Project Interaction Table C. Based on predictions and professional judgement, enter one of the following responses in the appropriate box on the Project Interaction Table:

[-] no interaction between VEC or VEC habitat and project disturbance; or

[ES] environmental significance assessed in Steps 7 and 8.

The rationale must be provided if you decide that no interaction is possible. This is accomplished by placing a number in the AT (Audit Trail) column as a cross-reference to a similarly-numbered statement in the Audit Trail Table (Step 6c).

Step 6c: Leave Audit Trail.

A column marked "AT" is provided under each of the four questions on Table D. Use this space to cross-reference (by number) your rationale for specific assumptions and conclusions to the Audit Trail (Table E).

The Audit Trail Table should be used to the maximum extent possible:

- to show calculations associated with the prediction of temporal and spatial overlap;

- to itemize the available evidence supporting specific conclusions; and

- to indicate the reliability and applicability of the information, if possible.

Also complete Table H by including a list of supporting references.

TABLE E

AUDIT TRAIL

PROJECT: _____

SHEET NO. ___ OF ___

NOTE NO.	CALCULATIONS, ASSUMPTIONS AND EVIDENCE	JUDGEMENT OF INFORMATION QUALITY Good Poor Unknown

3.7 Step 7a: Assess Environmental Significance of Each Interaction

Two tables (Tables F and G) are required to complete this step.

Use the flowchart of questions provided in Figure 2 to assess the environmental significance of each VEC-disturbance interaction. Various combinations of answers to these questions will lead to a ranked assessment of potential environmental significance, where Class 4 is the lowest rating and Class 1 is the highest (or potentially most serious) rating. The responses to each question should be recorded on Environmental Significance Tables F and G. The questions of environmental significance should be separately addressed for each VEC population (P) and its habitat (H). This is very important because the resulting assessments then consider both direct and indirect environmental consequences of each VEC-disturbance interaction.

The last question of the assessment flowchart addresses the recovery of VEC populations after dredging-related changes in survival or reproduction. If recovery of that portion of a VEC population (or its habitat) affected is expected to occur within one generation or less, the answer to Question 6 in the flowchart is "short-term". However, if recovery is expected to require more than one generation, the answer should be "long-term". If desired or warranted, "short" and "long" can be redefined, but the rationale for each category must be stated explicitly.

To assist in the assessment of environmental significance, a list of sub-questions is provided in Appendix IV for consideration and thought. The relevance of these sub-questions will vary to a certain extent with the VEC population that is being assessed.

FIGURE 2

ASSESSMENT PROCEDURE ENVIRONMENTAL SIGNIFICANCE

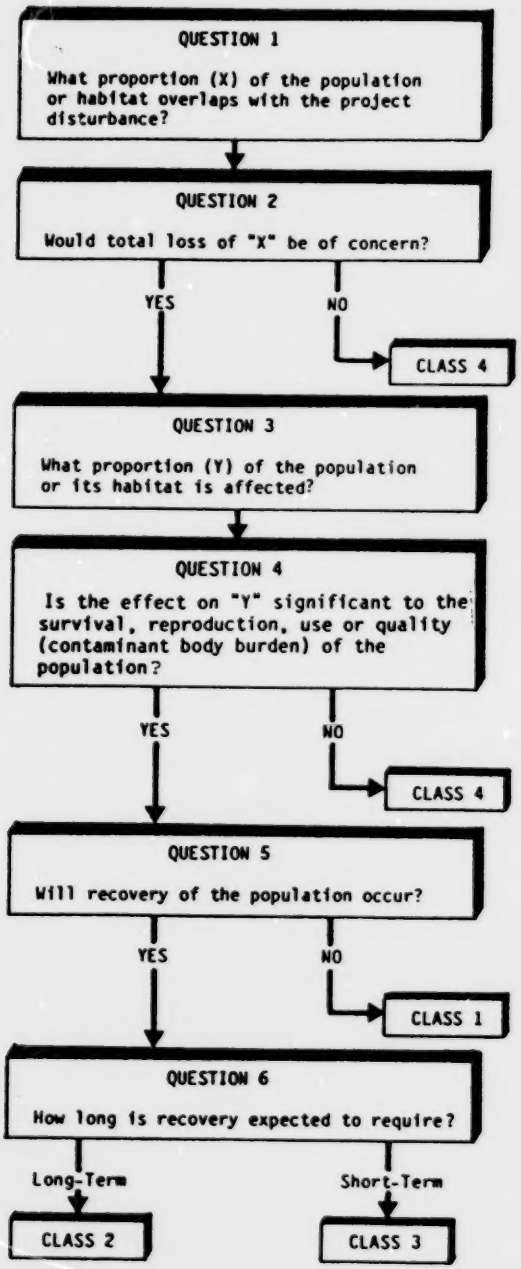


TABLE F

RESPONSE TO ENVIRONMENTAL SIGNIFICANCE QUESTIONS

PROJECT: _____

SHEET NO. ___of ___

VEC	POP. OR HAB. (Specify)	PROJECT DISTURBANCE	RESPONSE TO ENVIRONMENTAL SIGNIFICANCE QUESTIONS						ENVIRON. SIGNIFIC. CLASS	AT
			1	2	3	4	5	6		

AT = Audit Trail Cross-Reference (Table E)

TABLE G

ENVIRONMENTAL SIGNIFICANCE SUMMARY

PROJECT: _____

SHEET NO. ___ OF ___

VEC	PROJECT DISTURBANCE	ENVIRONMENTAL SIGNIFICANCE CLASS		
		POPULATION	HABITAT	AT

+ - denotes potential for cumulative effects due to other activities in the region.

AT - Audit Trail Cross-Reference (Table E)

TABLE H

REFERENCES

PROJECT: _____

SHEET NO.___ of ___

Step 7b: Judge Possibility of Cumulative Environmental Significance of each Interaction

Now consider the possibility that disturbances from other activities in the region may cause additive or synergistic effects on the same population or its habitat. Ask the following question:

- Would disturbances from other projects that occur at the same or a different time as the dredging increase the sensitivity of the VEC populations to dredging-related disturbances?

If the answer to this question is "yes", cumulative impact is possible and:

i) a "+" should be placed next to the appropriate class number in the Environmental Significance Table G; and

ii) a cross-reference number to the Audit Trail Table E should be included to explain the reasons for the potential cumulative impact.

Step 7c: Leave Audit Trail

As with predictions of spatial and temporal overlap, leave an audit trail for the assessment of environmental significance. The rationale for responses to the questions in Figure 2 should be briefly explained in Table E. Cross-reference these responses to the appropriate boxes in Table F.

3.8 Step 8: Assess Incremental Impact of Projects with a Duration Exceeding One Year

Projects extending beyond a one year period may cause a greater impact, particularly when the same population and habitat repeatedly interact with the same or different project disturbances. Unfortunately, assessing the ecological significance and cumulative impact of long-duration projects is difficult and subjective because:

- the degree of recovery from successive annual impact is rarely known;

- repeated exposure of populations and their habitats to impact sources may have;

  i) no incremental effects, if the population adapts to such sources of impact;

  ii) additive incremental effects, if different individuals of the same population are affected in successive years; or

  iii) multiplicative incremental effects, if repeated exposure increases the sensitivity of portions of the population to successive interactions with project activities.

Use new sets of Tables E, F, and G for assessing the ecological significance of interactions over the duration of the project. The questions on Figure 2 should be addressed again, but this time for those VEC-disturbance interactions that occur during the subsequent year(s) of the project. Provide an audit trail and state any uncertainties in the calculations.

Discuss anticipated incremental impact on the basis of available information and suggest which effects may be additive or multiplicative, and where adaptation to multi-year impact sources is considered possible.

3.9 Step 9: Summary

Prepare a brief (1-2 pages) written summary to accompany Tables A to H. The summary should include but not necessarily be limited to:

- Discussion of the overall significance of the dredging application based on the Classes of Environmental Significance summarized on Tables F and G;

- Identification of important data gaps and an estimation of the confidence of the assessor in the rankings of environmental significance given the uncertainties related to these data gaps;

- Consideration of the possibility of dredging activities reoccurring in subsequent years and the subsequent sensitization of species;

- Consideration of the disturbances in relation to natural changes in the environment (e.g. ice scour, Mackenzie River turbidity plume);

- Discussion of cumulative impact related to other projects in the same region at the same or different time that might increase the sensitivity of the VEC population to dredging;

- Consideration of natural stresses that may increase the susceptibility of VECs to these dredging-related disturbances; and

- Recommendations for mitigative measures. Users are referred to Thomas et al. (1985) for a thorough analysis of mitigative measures appropriate to Beaufort Sea dredging.

The process is intended to be iterative. If the assessor identifies significant environmental concerns that may be reduced by implementation of additional or more effective mitigative measures, the process may be repeated with the mitigative measures added to the project description to verify the reduced significance of environmental concerns. Results of the process with the original and revised (including mitigation) project descriptions could be submitted to justify a recommendation for a change in project timing or location for spoil deposition.

4.0 HYPOTHETICAL CASE STUDIES

This section illustrates an application of the process described in Part 3 to two hypothetical case studies. The case studies were completed in a preliminary form during a workshop held at the Freshwater Institute (Department of Fisheries and Oceans) in Winnipeg on December 12 and 13, 1985. Michael Lawrence coordinated the workshop and participated throughout the two days. Other participants attended the workshop for various periods of time and included the Scientific Authority for this study, Glen Packman EPS, Yellowknife and W. Bond, T. Strong, L. Lockhart, and B. Fallis from the Freshwater Institute. These case studies were subsequently revised by the authors to reflect recommended changes to the process that were formulated during the second project workshop on 6-7 March, 1986.

The project descriptions for the hypothetical case studies were defined and prepared by the Scientific Authority and include (1) the deepening of a hypothetical docking area in Tuktoyaktuk Harbour, and (2) the excavation of a subsea pipeline trench from Nipterk to North Head on Richards Island. These hypothetical projects were selected because they represent dredging activities that are feasible given current and proposed hydrocarbon exploration and production plans for the Beaufort Sea.

4.1 Case Study 1: Deepening of Dock Area in Tuktoyaktuk Harbour

This project would involve the deepening of a dock area in Tuktoyaktuk Harbour to 5 m (L.L.W.) to allow ships and dredges to load, unload and overwinter. An estimated 50,000 m^3 of bottom material would be moved and deposited in an adjacent bay (Figure 3). A suction dredge would complete the project over a period of approximately 4 days during September. The material to be dredged would be silt and mud containing several chemical contaminants at concentrations shown in Table 4-1. Substances identified in

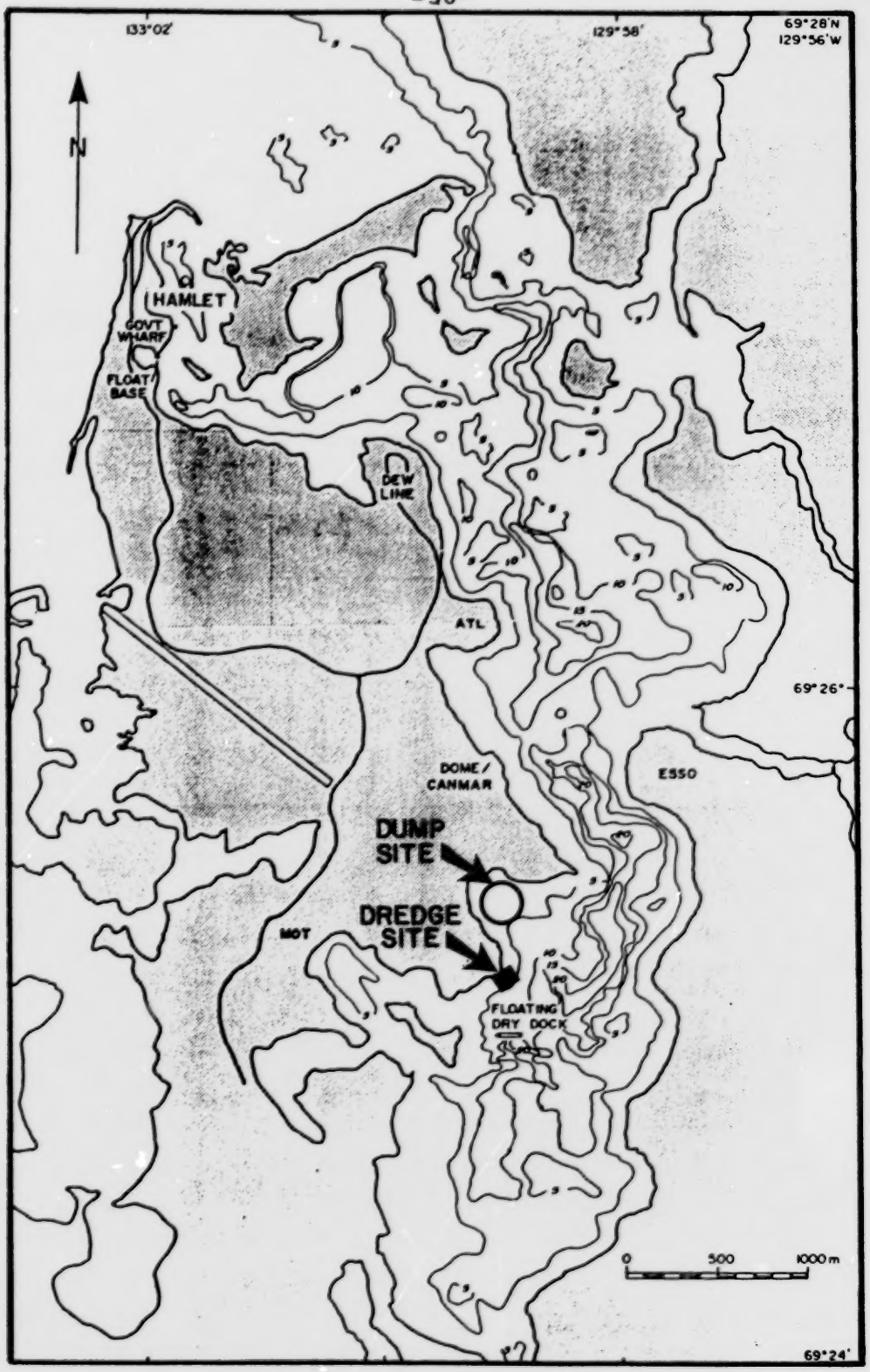


FIGURE 3

LOCATION OF HYPOTHETICAL DREDGE AND DUMP SITES IN TUKTOYAKTUK HARBOUR

TABLE 4-1

CONCENTRATIONS OF CONTAMINANTS AT VARIOUS DEPTHS IN A SEDIMENT CORE TAKEN FROM THE HYPOTHETICAL DREDGING SITE IN TUKTOYAKTUK HARBOUR

COMPOUND	CONTAMINANT CONCENTRATION (ppb) AND DEPTH IN CORE		
	0-5 cm	15-20 cm	28 cm
C12 Dodecane	189.2	198.2	55.9
C13 Tridecane	690.9	821.9	210.0
C14 Tetradecane	989.8	1223.9	242.9
C15 Pentadecane	1625.2	2259.6	605.7
C16 Hexadecane	964.4	1541.9	402.7
C17 Heptadecane	1433.8	2653.0	690.9
Pristane	*	2122.4	*
C18 Octadecane	1477.2	2705.3	716.8
Phytane	*	*	*
C19 Nonadecane	1949.1	3438.4	808.9
C20 Elcosane	1509.8	2091.3	434.4
C21 Heneicosane	2264.6	4183.4	680.7
C22 Docosane	2285.3	4874.3	510.7
C23 Tricosane	2571.3	5520.9	387.6
C24 Tetracosane	1599.6	3771.9	152.0
C25 Pentacosane	3908.4	9436.3	302.1
C26 Hexacosane	1849.3	3958.8	97.5
C27 Heptacosane	5623.5	14,495.7	393.2
C28 Octacosane	2380.8	4793.6	126.6
C29 Nonacosane	10,587.9	25,772.5	844.9
C30 Triacontane	3234.6	6608.7	182.1
C31 Undacontane	30,901.3	65,591.2	2374.2
C32 Dotriacontane	4008.2	6852.9	205.2
C33 Tricontane	173.8	370.5	2340.5
C34 Tetracontane	941.2	1852.4	426.3
C35 Pentacontane	753.0	2371.1	292.6
C36 Hexatriacontane	4605.9	8082.1	176.5
Hydrocarbon Total	88,518.1	185,469.3	13,660.8

* - Background Interference
ND - Not detected
TR - Below Detection Limit

TABLE 4-1 (continued)

COMPOUND	CONTAMINANT CONCENTRATION (ppb) AND DEPTH IN CORE		
	0-5 cm	15-20 cm	28 cm
Napthalene	50.83	47.39	102.01
Acenapthene	6.59	7.05	7.20
Fluorene	16.35	11.74	4.81
Phenanthrene	55.78	36.91	45.53
Anthracene	3.38	2.89	2.90
Fluoranthene	24.08	22.60	15.05
Pyrene	22.84	24.43	27.00
Chrysene	4.93	5.69	6.86
Benzo(a)Anthracene	22.50	28.36	36.13
Napthacene	6.57	TR	9.73
Benzo (K) Fluoranthene	7.87	TR	15.56
Benzo (B) Fluoranthene	19.25	22.20	ND
Benzo (E) Pyrene	30.24	35.71	27.79
Benzo (a) Pyrene	5.33	6.16	10.00
Erylene	76.15	42.50	50.02

Schedules I and II of the Ocean Dumping Control Act are present at the following concentrations: cadmium (0.6 mg/kg), oi and grease (150 mg/kg) and n-hexane extractable hydrocarbons (13,660-185,469 ppb). No other details were provided with the application and several other assumptions were necessary to complete the case study. These assumptions and project description information relevant to the assessment of biological effects are summarized in Table A.

TABLE A

PROJECT DESCRIPTION

PROJECT: DEEPENING OF DOCK AREA IN TUKTOYAKTUK HARBOUR

PROJECT SCHEDULE: 4 Days - September 1 - 30

ASSESSOR: Workshop ORGANIZATION: DFO/EPS DATE: December 1985

SHEET NO. 1 OF 3

PROJECT DISTURBANCE	MITIGATIVE MEASURE(S)	INFORMATION SOURCE*
Dredging		
. no alteration of sediment composition would occur; sediment at dredge and dump sites is similar	-	4
. altered bottom contours would occur in an area approximately 150 m x 100 m, and since dredging would occur close to shore without adequate shore stabilization, slumping of nearshore areas would result from the project	-	3,4
. increased suspended sediments and turbidity at dredge site would be limited to near bottom waters adjacent to the suction head	-	5
. suction currents would occur near the head	-	1
. underwater noise would be generated	-	1
. physical presence of dredge could disturb VECs	-	1

* Indicate: 1-5, (1) Application, (2) Communication from Applicant, (3) Calculation, (4) Assumption (Add other categories as required.), or (5) Thomas *et al.* (1985)

TABLE A

PROJECT DESCRIPTION

PROJECT: DEEPENING OF DOCK AREA IN TUKTOYAKTUK HARBOUR

SHEET NO. 2 OF 3

PROJECT DISTURBANCE	MITIGATIVE MEASURE(S)	INFORMATION SOURCE*
Dumping		
. altered bottom contours would occur in an area approximately 300 m x 200 m and spoil thickness would be about 0.75 m	-	3
. increased suspended sediment and turbidity levels would affect an area of approximately 1 km radius from the dredge outfall	-	5
. decreased dissolved oxygen levels would be unlikely to result from the activity; spoil BOD is assumed to be low	-	4
. resuspension of toxic chemicals would be possible due to concentrations of cadmium and hydrocarbons reported in Table 4-1	-	1
. increased nutrient concentrations would be unlikely	-	1

* Indicate: 1-5, (1) Application, (2) Communication from Applicant, (3) Calculation, (4) Assumption (Add other categories as required.), or (5) Thomas *et al.* (1985)

TABLE A

PROJECT DESCRIPTION

PROJECT: DEEPENING OF DOCK AREA IN TUKTOYAKTUK HARBOUR

SHEET NO. 3 OF 3

PROJECT DISTURBANCE	MITIGATIVE MEASURE(S)	INFORMATION SOURCE*
. underwater noise would be generated	-	1
. alteration of vertical temperature and salinity stratification would be temporary	-	4
. settling and flocculation of suspended sediment would occur in an area of approximately 500 m radius of the dredge outfall	-	5
. altered sediment composition could occur, dredged spoil would be placed such that cleaner, less contaminated sediments from depths greater than the 28 cm core sample (Table 4-1) would cover contaminated sediments at the dump site, although some contaminants would still occur in the surface sediments and be biologically available	-	4
. physical presence of pipeline at spoil site could disturb VECs	-	1

* Indicate: 1-5, (1) Application, (2) Communication from Applicant, (3) Calculation, (4) Assumption (Add other categories as required.), or (5) Thomas *et al.* (1985)

TABLE B

RATIONALE FOR SELECTION OF VALUED ECOSYSTEM COMPONENTS (VECs)

PROJECT: DEEPENING OF DOCK AREA IN TUKTOYAKTUK HARBOUR

SHEET NO. 1 OF 1

VEC Common/Scientific Names	RATIONALE FOR SELECTION
Broad Whitefish *Coregonus nasus*	Harvested in domestic fishery Economic importance and social importance
Arctic Cisco *Coregonus autumnalis*	Harvested in domestic fishery for human use and dog food
Pacific Herring *Clupea hargenus pallasi*	Potential for future fishery Biologically important because (1) the population may be resident year-round in the Harbour and (2) fatty tissues may bioaccumulate contaminants
Starry Flounder *Platichthys stellatus*	Ecologically important because the population may be resident year-round in Tuktoyaktuk Harbour

TABLE C

PROJECT INTERACTION

PROJECT: DEEPENING OF DOCK AREA IN TUKTOYAKTUK HARBOUR

SHEET NO. 1 OF 1

PROJECT DISTURBANCES	VALUED ECOSYSTEM COMPONENTS											
	Broad Whitefish			Arctic Cisco			Starry Flounder			Pacific Herring		
	P*	H**	AT	P	H	AT	P	H	AT	P	H	AT
DREDGING												
. Entrainment	ES	-		ES	-		ES	-		ES	-	
. Siltation	ES	ES		ES	ES		ES	ES		-	-	23
. Altered Bottom Contours	-	ES		-	ES		-	ES		-	-	21
. Underwater Noise	-	-	29	-	-		-	-		-	-	
. Physical Presence	-	-	30	-	-		-	-		-	-	
DUMPING												
. Altered Bottom Contours	-	ES		-	ES		-	ES		-	-	21
. Contaminant Release	ES	ES		ES	ES		ES	ES		ES	ES	

* population
** habitat
ES environmental significance assessed
\- no interaction
29 see Table E Audit Trail

TABLE D

SPATIAL AND TEMPORAL OVERLAP

PROJECT: DEEPENING OF DOCK AREA IN TUKTOYAKTUK HARBOUR

SHEET NO. 1 OF 2

VEC/ DISTURBANCE (List)	SPATIAL OVERLAP						TEMPORAL OVERLAP					
	POPULATION			HABITAT			POPULATION			HABITAT		
	<10p	>10p	AT	<10p	>10p	AT	<10p	>10p	AT	<10p	>10p	AT
Broad Whitefish/ Entrainment	X		1			2	X		3			2
Broad Whitefish/ Siltation	X		1	X		4	X		3		X	5
Broad Whitefish/ Altered Bottom Contours				X		4					X	5
Broad Whitefish/ Contaminant Release	X		1	X		4	X		3,6		X	5
Arctic Cisco/ Entrainment	X		7				X		8			
Arctic Cisco/ Siltation	X		7	X		9	X		8		X	5
Arctic Cisco/ Altered Bottom Contours				X		9					X	5

TABLE D

SPATIAL AND TEMPORAL OVERLAP

SHEET NO. 2 of 2

VEC/ DISTURBANCE (List)	SPATIAL OVERLAP						TEMPORAL OVERLAP					
	POPULATION			HABITAT			POPULATION			HABITAT		
	<10p	>10p	AT	<10p	>10p	AT	<10p	>10p	AT	<10p	>10p	AT
Arctic Cisco/ Contaminant Release	X		7, 10	X		9		X	11		X	5, 11
Starry Flounder/ Entrainment	X		12				X		13			
Starry Flounder/ Siltation	X		14	X		15	X		13		X	16
Starry Flounder/ Altered Bottom Contours (Removal)				X		17					X	16
Starry Flounder/ Altered Bottom Contours (Placement)	X		14	X		14, 15	X		13		X	16
Starry Flounder/ Contaminant Release	X		18	X		19		X	20		X	16
Pacific Herring/ Entrainment	X		21				X		22			
Pacific Herring/ Contaminant Release	X		21	X		19		X	20		X	16

AT = Audit Trail Cross-Reference (Table E)
p = percent

TABLE E

AUDIT TRAIL

PROJECT: DEEPENING OF DOCK AREA IN TUKTOYAKTUK HARBOUR

SHEET NO. 1 OF 7

NOTE NO.	CALCULATIONS, ASSUMPTIONS AND EVIDENCE	JUDGEMENT OF INFORMATION QUALITY Good Poor Unknown
1	During September, small numbers of broad whitefish may move through Tuktoyaktuk Harbour during their migration to overwintering areas in the Mackenzie River system. The size of the Beaufort Sea population of broad whitefish is not known, but the proportion of this population that would enter Tuktoyaktuk Harbour and encounter the dredging and dumping activities would be small. For example, nearshore gillnet sets in September, 1980, near the proposed dredging location in the Harbour caught 4-9 broad whitefish/hour (Bond 1982).	X
2	Entrainment would not directly affect fish habitat in the Harbour.	X
3	Broad whitefish may use the Harbour from May through October; therefore, the temporal overlap would be 4 d/180 d X 100 = 2 percent.	X
4	The Harbour is not critical rearing and feeding habitat, but part of a migration route for broad whitefish to the Mackenzie River system. Since the available habitat along the coast is extensive the proportion of the habitat affected by this dredging project would be insignificant.	X

TABLE E

AUDIT TRAIL

SHEET NO. 2 OF 7

NOTE NO.	CALCULATIONS, ASSUMPTIONS AND EVIDENCE	JUDGEMENT OF INFORMATION QUALITY Good Poor Unknown
[illegible]	Although a very small proportion of the available habitat would be affected by the project, effects of siltation, slumping and bio-availability of contaminants for an unknown period following the dredging and dumping, would result in a temporal overlap between the project and fish habitat of greater than 10 percent.	X
[illegible]	Bond (1982) sampled fish in Tuktoyaktuk Harbour between 25 July 1979 and 23 March 1981 and found that 88 percent of broad whitefish stomachs examined were empty. Since small numbers of broad whitefish use this habitat temporarily during migration and these fish may not be feeding during their stay in the Harbour, the temporal overlap of the population with contaminants would likely be less than the 2 percent calculated in Note 3.	X
[illegible]	Bond (1982) reported that a large in-migration of Arctic cisco to Tuktoyaktuk Harbour occurred during September. The proportion of the Beaufort Sea population of Arctic cisco that use the Harbour is unknown, although it would probably be relatively small.	X
[illegible]	Bond's (1982) studies indicated that Arctic cisco may utilize the Harbour year-round. Some of the September migrants overwinter in the deep marine waters of the Harbour and young-of-the-year were present during the summer months. Therefore, the temporal overlap of the project and the Arctic cisco population in the Harbour would be 4 d/365 d X 100 = 1 percent	X
[illegible]	Since the Arctic cisco population is widely distributed throughout the coastal Beaufort Sea during the summer and in the Mackenzie River system during other periods of the year, the spatial overlap of the project and their habitat would be relatively small.	X

TABLE E

AUDIT TRAIL

SHEET NO. 3 OF 7

NOTE NO.	CALCULATIONS, ASSUMPTIONS AND EVIDENCE	JUDGEMENT OF INFORMATION QUALITY Good Poor Unknown
10	The overwintering Arctic cisco would be most vulnerable to possible effects of contaminants due to their restricted winter habitat and food sources. However, they feed primarily in deeper (8-12 m) marine areas of the Harbour, beyond the influence of the dredging project. (W. Bond pers. comm.)	X
11	The availability of contaminants to Arctic cisco could extend beyond the period of the dredging project. Some of the contaminants could be accumulated by prey (polychaetes) and Arctic cisco might be exposed to these contaminants indirectly through their prey for an unknown period of time. Because relatively large numbers of Arctic cisco use Tuktoyaktuk Harbour annually, it is possible that more than 10 percent of the regional population could be exposed to contaminants.	X
12	The starry flounder population in Tuk Harbour may be a resident population with some in- and out-migration occurring annually (W. Bond pers. comm.). If it is assumed that flounders are evenly distributed in the harbour and the portion of the population vulnerable to entrainment is equivalent to the proportion of the habitat disturbed, then less than 1 percent of the population would be suceptible to entrainment. Calculation of spatial overlap is: $\frac{1500\ m^2\ \text{(dredged area)}}{11\ km^2\ \text{(area of the Harbour)}} \times 100 = 0.1$ percent Based on catch-per-unit-effort changes for nearshore sites in Tuk Harbour (Bond 1982), flounders may move away from shallow shoreline areas into deeper marine water in the Harbour after July and August (W. Bond, pers. comm.). Small mesh trap net catches along the shoreline of Tuk Harbour showed a decrease in the smaller size classes of starry flounder in September (Hopky and Ratynski 1983). Therefore, a smaller and less vulnerable proportion of the population may be exposed to entrainment.	X

TABLE E

AUDIT TRAIL

SHEET NO. 4 OF 7

NOTE NO.	CALCULATIONS, ASSUMPTIONS AND EVIDENCE	JUDGEMENT OF INFORMATION QUALITY Good	Poor	Unknown
13	Since starry flounders occupy Tuk Harbour year-round the temporal overlap with the dredging project would be 1 percent. $\frac{4 \text{ days}}{365 \text{ days}} \times 100 = 1$ percent	X		
14	Siltation effects at the dump site could affect an area within approximately a 500 m radius from the dredge outfall. The spatial overlap would be: $\frac{(500m)^2 \times 3.14}{11 \text{ km}^2 \text{ (Area of Tuk Harbour)}} \times 100 = 7$ percent Since the population of starry flounder may not be evenly distributed in the harbour during September (see Note 12) less than 7 percent of the population may be vulnerable. Some larvae may be present in the water column during September (Ratynski 1983) and they may be more vulnerable than adults.		X	
15	The spatial overlap for habitat vulnerable to siltation and sediment placement effects would be the same as that calculated for the population (see Note 14).	X		
16	Effects of siltation, contaminants and sediment placement and removal at the dredge and disposal sites would affect the habitat for an unknown period of time beyond the duration of the dredging project.			X
17	The spatial overlap of habitat vulnerable to sediment removal would be less than 1 percent based on information provided in Note 12.	X		
18	The proportion of the population vulnerable to effects from contaminant release would probably not exceed the relative proportion of the area at the disposal site to the area of Tuk Harbour (see notes 12 and 14).			X

TABLE E

AUDIT TRAIL

SHEET NO. 5 OF 7

NOTE NO.	CALCULATIONS, ASSUMPTIONS AND EVIDENCE	JUDGEMENT OF INFORMATION QUALITY Good	Poor	Unknown
19	The area vulnerable to contaminant release would be limited to the disposal site and the area affected by siltation. The spatial overlap would be over estimated if it was calculated as the 500 m radius circle defined for siltation effects (see Note 14).	X		
20	Some contaminants may be biologically available at the disposal site for an unknown period after completion of the project. Since starry flounder and Pacific herring are year-round residents in the Harbour, more than 10 percent of the population could be exposed to contaminants over the period of a year following the project.		X	
21	Catch-per-unit-effort (CPUE) data indicate that Pacific herring are not abundant in nearshore areas, such as the dredging and dumping sites. CPUE values for this species were highest offshore, and at midwater depths (Bond 1982; Hopky and Ratynski 1983).	X		
22	Pacific herring occupy Tuk Harbour year-round with some seasonal migrations in and out of the Harbour associated with spawning and overwintering (Bond 1982). The temporal overlap of the population with the dredging project would be 1 percent (based on previous calculations).	X		
23	The area vulnerable to siltation has been calculated previously as less than 10 percent of the available habitat in Tuk Harbour. Since Pacific herring apparently do not extensively use shoreline habitats (see Note 21), this interaction was not assessed.	X		
24	The mortality of the fish entrained would be unlikely to result in any long-term effects to the population.	X		

TABLE E

AUDIT TRAIL

SHEET NO. 6 OF 7

NOTE NO.	CALCULATIONS, ASSUMPTIONS AND EVIDENCE	JUDGEMENT OF INFORMATION QUALITY		
		Good	Poor	Unknown
25	Exposure of broad whitefish to contaminants would be very short-term and adverse effects on individuals would be unlikely.	X		
26	Some contaminants could be available for uptake by prey species for an unknown period following the project and could then be accumulated by broad whitefish. However, evidence to support this assumption was not thoroughly examined.		X	
27	Some individual arctic cisco could accumulate contaminants from prey. Arctic ciscos are year-round residents in the Harbour, and some fish could accumulate amounts of contaminants that could cause other sublethal effects. The rate of recovery would then depend on the exposure of individuals to any particular contaminant, and subsequent uptake and effects, if any.			X
28	More than 10 percent of the starry flounder population could occupy the habitat affected by contaminant release during the year of the project. The percent of the population affected could be less than 10 percent because preferential feeding by flounders in affected habitat would probably be necessary to cause detectable contaminant uptake due to this disturbance. The rate of recovery would be dependent upon exposure of individuals to particular contaminants and subsequent uptake and sublethal effects, if any. Class 2 was based on worst case assumptions for uncertainties regarding duration of availability, concentrations and potential for bioaccumulation of contaminants.		X	

TABLE E

AUDIT TRAIL

SHEET NO. 7 OF 7

NOTE NO.	CALCULATIONS, ASSUMPTIONS AND EVIDENCE	JUDGEMENT OF INFORMATION QUALITY Good Poor Unknown
29	Underwater noise can adversely affect fish, however, dredge-created noise has not been identified as a source of disturbance to fish in the literature describing dredging effects and therefore the environmental significance of interaction was not assessed	X
30	There is no evidence in the available literature that the physical presence of the dredge would disturb fish.	X
31	A range of contaminants enter Tuktoyaktuk Harbour as a result of various activities in the area (e.g. sewage discharge, chronic oil releases etc). The potential for cumulative impact exists due to synergistic or additive effects of multiple contaminants in receiving waters of the harbour.	X

TABLE F

RESPONSE TO ENVIRONMENTAL SIGNIFICANCE QUESTIONS

PROJECT: DEEPENING OF DOCK AREA IN TUKTOYAKTUK HARBOUR

SHEET NO. 1 of 3

VEC	POP. OR HAB. (Specify)	PROJECT DISTURBANCE	RESPONSE TO ENVIRONMENTAL SIGNIFICANCE QUESTIONS						ENVIRON. SIGNIFIC. CLASS	AT
			1	2	3	4	5	6		
Broad Whitefish	POP	Entrainment	<10	No					Class 4	24
Broad Whitefish	POP	Siltation	<10	No					Class 4	
Broad Whitefish	HAB	Siltation	<10	No					Class 4	
Broad Whitefish	HAB	Altered Bottom Contours	<10	No					Class 4	
Broad Whitefish	POP	Contaminant Release	<10	No					Class 4	25
Broad Whitefish	HAB	Contaminant Release	<10	No					Class 4	26
Arctic Cisco	POP	Entrainment	<10	No					Class 4	24
Arctic Cisco	POP	Siltation	<10	No					Class 4	
Arctic Cisco	HAB	Siltation	<10	No					Class 4	

AT = Audit Trail Cross-Reference (Table E)

TABLE F

RESPONSE TO ENVIRONMENTAL SIGNIFICANCE QUESTIONS

PROJECT: DEEPENING OF DOCK AREA IN TUKTOYAKTUK HARBOUR

SHEET NO. 2 of 3

VEC	POP. OR HAB. (Specify)	PROJECT DISTURBANCE	RESPONSE TO ENVIRONMENTAL SIGNIFICANCE QUESTIONS						ENVIRON. SIGNIFIC. CLASS	AT
			1	2	3	4	5	6		
Arctic Cisco	HAB	Altered Bottom Contours	<10	No					Class 4	
Arctic Cisco	POP	Contaminant Release	<10	No					Class 4	27
Arctic Whitefish	HAB	Contaminant Release	<10	No					Class 4	
Starry Flounder	POP	Entrainment	<1	No					Class 4	24
Starry Flounder	POP	Siltation	<10	No					Class 4	
Starry Flounder	HAB	Siltation	<10	No					Class 4	
Starry Flounder	POP	Altered Bottom Contours	<10	No					Class 4	
Starry Flounder	POP	Contaminant Release	>10	Yes	<10	Yes	Yes	LT	Class 2	28
Starry Flounder	HAB	Contaminant Release	<10	No					Class 4	

AT = Audit Trail Cross-Reference (Table E)

TABLE F

RESPONSE TO ENVIRONMENTAL SIGNIFICANCE QUESTIONS

PROJECT: DEEPENING OF DOCK AREA IN TUKTOYAKTUK HARBOUR

SHEET NO. 3 of 3

VEC	POP. OR HAB. (Specify)	PROJECT DISTURBANCE	RESPONSE TO ENVIRONMENTAL SIGNIFICANCE QUESTIONS						ENVIRON. SIGNIFIC. CLASS	AT
			1	2	3	4	5	6		
Pacific Herring	POP	Entrainment	<10	No					Class 4	24
Pacific Herring	POP	Contaminant Release	<10	No					Class 4	
Pacific Herring	HAB	Contaminant Release	<10	No					Class 4	

AT = Audit Trail Cross-Reference (Table E)

TABLE G

ENVIRONMENTAL SIGNIFICANCE SUMMARY

PROJECT: DEEPENING OF DOCK AREA IN TUKTOYAKTUK HARBOUR

SHEET NO. 1 OF 2

VEC	PROJECT DISTURBANCE	ENVIRONMENTAL SIGNIFICANCE CLASS		
		POPULATION	HABITAT	AT
Broad Whitefish	Entrainment	Class 4	-	
Broad Whitefish	Siltation	Class 4	Class 4	
Broad Whitefish	Altered Bottom Contours	-	Class 4	
Broad Whitefish	Contaminant Release	Class 4+	Class 4+	31
Arctic Cisco	Entrainment	Class 4	-	
Arctic Cisco	Siltation	Class 4	Class 4	
Arctic Cisco	Altered Bottom Contours	-	Class 4	
Arctic Cisco	Contaminant Release	Class 4+	Class 4+	31

+ - denotes potential for cumulative effects due to other activities in the region

AT - Audit Trail Cross - Reference (Table E)

TABLE G

ENVIRONMENTAL SIGNIFICANCE SUMMARY

PROJECT: DEEPENING OF DOCK AREA IN TUKTOYAKTUK HARBOUR

SHEET NO. 2 OF 2

VEC	PROJECT DISTURBANCE	ENVIRONMENTAL SIGNIFICANCE CLASS		
		POPULATION	HABITAT	AT
Starry Flounder	Entrainment	Class 4	-	
Starry Flounder	Siltation	Class 4	Class 4	
Starry Flounder	Altered Bottom Contours	-	Class 4	
Starry Flounder	Contaminant Release	Class 2+	Class 4 +	31
Pacific Herring	Entrainment	Class 4	-	
Pacific Herring	Contaminant Release	Class 4+	Class 4+	31

+ - denotes potential for cumulative effects due to other project disturbances in the region.

AT - Audit Trail Cross - Reference (Table E)

TABLE H

REFERENCES

PROJECT: DEEPENING OF DOCK AREA IN TUKTOYAKTUK HARBOUR

SHEET NO. 1 of 1

Bond, W.A. 1982. A study of the fishery resources of Tuktoyaktuk Harbour, southern Beaufort Sea coast, with special reference to life histories of anadromous coregonids. Canadian Technical Report of Fisheries and Aquatic Sciences No. 119. 90 pp.

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SUMMARY

DEEPENING OF DOCK AREA IN TUKTOYAKTUK HARBOUR

The most significant concern related to this project would be the potential bioaccumulation of contaminants by starry flounder. There are a number of uncertainties regarding the Class 2 environmental significance ranking of this effect. Information deficiencies include: (1) the period of bioavailability of contaminants in the water column and sediments; (2) concentrations of contaminants in the water column and sediments during and after dredging; (3) the potential for bioaccumulation of contaminants; (4) biological fate of accumulated contaminants; and (5) the rate of recovery due to detoxification and depuration of contaminants. In view of these data gaps, environmental significance rankings are considered speculative and a range of environmental significance classes between 2 and 4 more closely approximates the degree of precision possible given the available data.

A range of contaminants enter Tuktoyaktuk Harbour as a result of various activities in the area (e.g. sewage discharge, chronic oil releases etc.). The potential for cumulative impact exists due to synergistic or additive effects of multiple contaminants in receiving waters of the harbour.

Starry flounder are important primarily due to the possible genetic isolation of this population in Tuk Harbour, and given the low significance of concerns regarding other species and the uncertainty regarding the degree of effects on starry flounder, no mitigation was proposed by the assessment team. The short duration of this project would minimize the potential for cumulative or incremental effects. However, the potential for shoreline slumping as a result of the project was identified by the group, and possible mitigative measures were recommended to protect important nearshore habitats.

4.2 CASE STUDY 2: NIPTERK - RICHARDS ISLAND PIPELINE TRENCH

This hypothetical project would involve the excavation of a pipeline trench from Nipterk to North Head on Richards Island (Figure 4). The linear distance of the trench would be approximately 35 km and the water depth at Nipterk is about 8.2 m. The trench would be excavated to 3 m below the sea bottom and have side slopes of approximately 3:1. The material to be dredged would be silt and clay, and the substances listed in Schedules I and II of the Ocean Dumping Control Act would not be present at concentrations exceeding ODCA regulated limits. The work in water more than 1.5 m deep would be carried out by a cutter suction dredge and the entire project would be expected to require two summers and winters, with summer dredging occurring between July 1 and September 30. Both the nearshore trench (water depth < 1.5 m) and shoreline connection would be completed during winter with bucket dredges operating from the landfast ice platform. The volume of material from the pipeline trench would be approximately 1 million m^3 and the material would be side cast. The dumping would be continuous. The scenario was provided by the Scientific Authority as an example of what might be provided by a contractor.

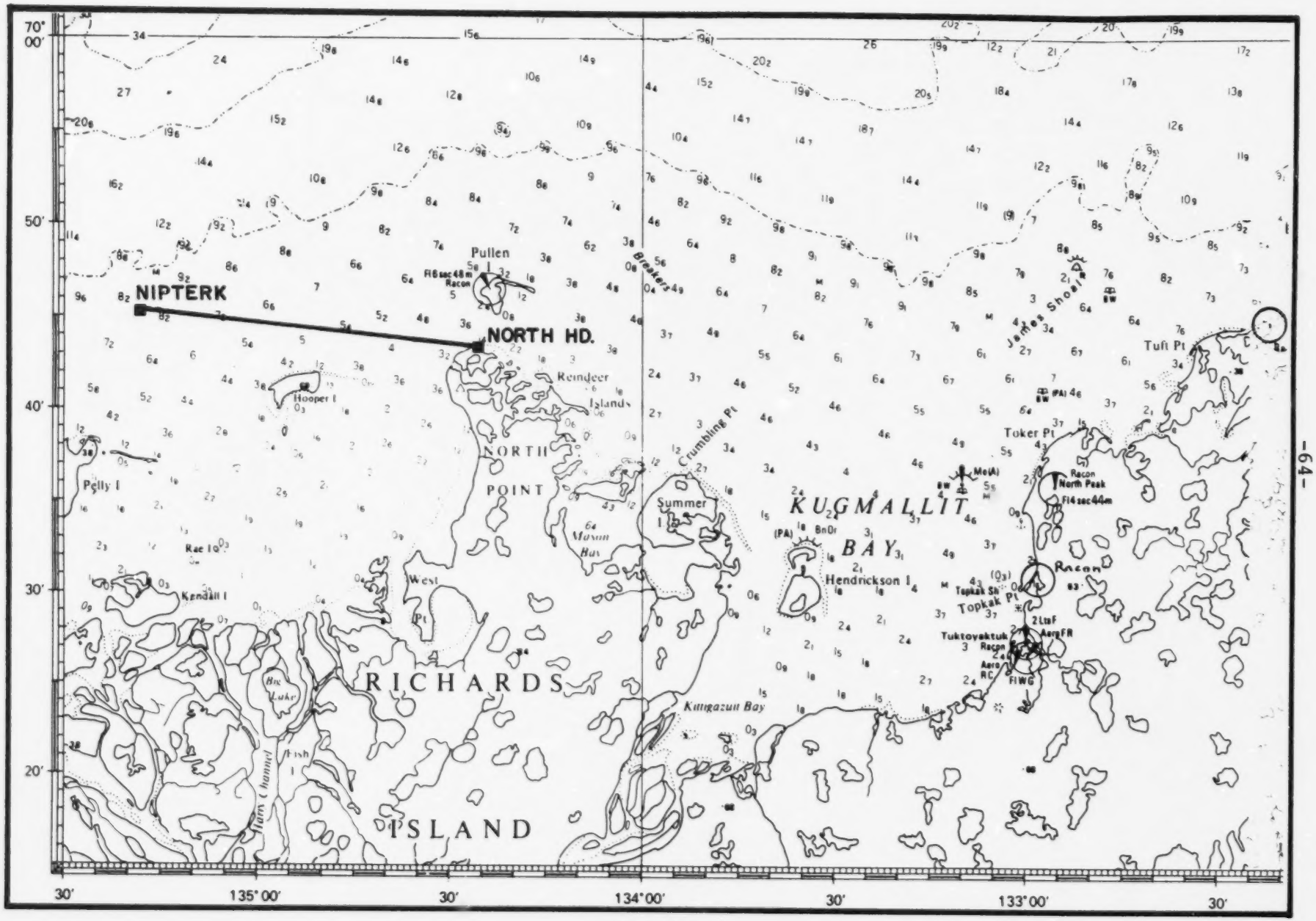

FIGURE 4

LOCATION OF HYPOTHETICAL PIPELINE TRENCH FROM NIPTERK TO NORTH HEAD, RICHARDS ISLAND

TABLE A

PROJECT DESCRIPTION

PROJECT: NIPTERK-RICHARDS ISLAND PIPELINE TRENCH

PROJECT SCHEDULE: 2 summers, July 1 to September 30 and two winters

ASSESSOR: Workshop ORGANIZATION: DFO DATE: December 1985

SHEET NO. 1 OF 3

PROJECT DISTURBANCE	MITIGATIVE MEASURE(S)	INFORMATION SOURCE*
DREDGING		
. no alteration of sediment composition; spoil side-cast with natural infilling of trench	-	4
. altered bottom contours would occur for the duration of the project	-	1
. increased suspended sediments and turbidity at dredge site would be limited to near bottom waters adjacent to the cutter head during summer activities. Limited water under ice during winter dredging, but bucket dredges cause turbidity throughout the water column	-	5
. suction currents would occur near the cutter head	-	1
. underwater noise would be generated	-	4
. physical presence of dredge could disturb VECs	-	1
DUMPING		
. altered bottom contours would occur for the duration of the project	-	4
. increased suspended sediment and turbidity would affect an area within approximately 1 km radius from the dredge outfall	-	5

* See page 67

TABLE A

PROJECT DESCRIPTION

PROJECT: NIPTERK-RICHARDS ISLAND PIPELINE TRENCH

PROJECT SCHEDULE: 2 summers, July 1 to September 30 and two winters

ASSESSOR: Workshop ORGANIZATION: DFO DATE: December 1985

SHEET NO. 2 OF 3

PROJECT DISTURBANCE	MITIGATIVE MEASURE(S)	INFORMATION SOURCE*
. decreased dissolved oxygen levels would be unlikely to result from the activity; spoil BOD assumed to be low	-	4
. resuspension of toxic chemicals is assumed to be unlikely	-	4
. increased nutrient concentrations would not likely be a concern, because natural turbidity probably limits primary production in this area	-	7
. underwater noise would be generated	-	1
. alteration of vertical temperature and salinity stratification would be temporary since variable stratification occurs in this estuarine area during summer. This disturbance would be unlikely to cause variations that exceed normal background variability	-	6
. settling and flocculation of suspended sediment would occur within an area of approximately 500 m radius from the dredge outfall	-	5

* See page 67

TABLE A

PROJECT DESCRIPTION

PROJECT: NIPTERK-RICHARDS ISLAND PIPELINE TRENCH

PROJECT SCHEDULE: 2 summers, July 1 to September 30 and two winters

ASSESSOR: Workshop ORGANIZATION: DFO DATE: December 1985

SHEET NO. 3 OF 3

PROJECT DISTURBANCE	MITIGATIVE MEASURE(S)	INFORMATION SOURCE*
. altered sediment composition would be unlikely because spoil discharge is adjacent to dredge location	-	1
. physical presence of dredge could disturb VECs	-	1

* Indicate 1-7, (1) Application, (2) Communication from Applicant, (3) Calculation, (4) Assumption (Add other categories as required), (5) Thomas et al. (1985), (6) Slaney (1976), (7) D. Thomas, pers. comm.

TABLE B

RATIONALE FOR SELECTION OF VALUED ECOSYSTEM COMPONENTS (VECs)

PROJECT: NIPTERK-RICHARDS ISLAND PIPELINE TRENCH

SHEET NO. 1 OF 1

VEC Common/Scientific Names	RATIONALE FOR SELECTION
Beluga Whale *Delphinapterus leucas*	Social and economic importance, harvested for domestic use
Arctic Cisco *Coregonus autumnalis*	Social and economic importance, harvested for domestic use
Rainbow Smelt *Osmerus mordax*	Ecological importance, food source for beluga whale
Broad Whitefish *Coregonus nasus*	Social and economic importance, harvested for domestic use

TABLE C

PROJECT INTERACTION

PROJECT: NIPTERK-RICHARDS ISLAND PIPELINE TRENCH

SHEET NO. 1 OF 1

PROJECT DISTURBANCES	VALUED ECOSYSTEM COMPONENTS											
	BELUGA WHALE			ARCTIC CISCO			RAINBOW SMELT			BROAD WHITEFISH		
	P*	H**	AT	P	H	AT	P	H	AT	P	H	AT
DREDGING AND DUMPING												
. Noise	ES	ES	-	-	-	23	-	-	23	-	-	23
. Physical Presence	ES	ES	-	-	-	24	-	-	24	-	-	24
. Turbidity/Sus. Sediments	-	-	1	ES	-	15	ES	-	15	ES	-	15
. Entrainment	-	-	-	ES	-	-	ES	-	-	ES	-	-
. Altered Bottom Contours	-	-	22	-	-	-	-	-	-	-	-	-

* population
** habitat
ES Interaction probable and environmental significance assessed
\- No interaction
1 See Table E Audit Trail

TABLE D

SPATIAL AND TEMPORAL OVERLAP

PROJECT: NIPTERK-RICHARDS ISLAND PIPELINE TRENCH

SHEET NO. 1 OF 1

VEC/DISTURBANCE (List)	SPATIAL OVERLAP						TEMPORAL OVERLAP					
	POPULATION			HABITAT			POPULATION			HABITAT		
	<10p	>10p	AT	<10p	>10p	AT	<10p	>10p	AT	<10p	>10p	AT
Beluga Whale/ Noise		X	2	X		3		X	4	X		5
Beluga Whale/ Physical Presence		X	6	X		3		X	4	X		5
Arctic Cisco/ Entrainment	X		12					X	13			
Arctic Cisco/ Turbidity/ Suspended Sediments	X		14			15		X	13			15
Rainbow Smelt/ Entrainment	X		16					X	17			
Rainbow Smelt/ Turbidity/ Suspended Sediment	X		16			15		X	17			15
Broad Whitefish/ Entrainment	X		18				X		18			
Broad Whitefish/ Turbidity/ Suspended Sediments	X		18			15	X		18			15

AT = Audit Trail Cross-Reference (Table E)
p = percent

TABLE E

AUDIT TRAIL

PROJECT: NIPTERK RICHARDS ISLAND PIPELINE TRENCH

SHEET NO. 1 OF 5

NOTE NO.	CALCULATIONS, ASSUMPTIONS AND EVIDENCE	JUDGEMENT OF INFORMATION QUALITY Good Poor Unknown
1	The dredging and dumping activities occur in the same location and disturbances due to both activities are considered simultaneously in the following assessment. It is expected that beluga whales would not be able to distinguish between dredge-created turbidity plumes and the turbid water in the Mackenzie River estuary. Beluga whales are primarily fish eaters and siltation and smothering would not be expected to have a direct adverse effect on their food sources.	X
2	Noise generated by dredges and air- and water-based support craft was considered. The audible distance of this noise to whales in the turbid shallow waters of the estuary is not precisely known. Behavioural responses of beluga whales to ship movements have been documented at a distance of 2.4 km from an activity (DIAND and Environment Canada, 1984). Disturbance could occur at even greater distances. The Beaufort Sea population of beluga whales is estimated to be 11,500. Whales are present in the Mackenzie Estuary from June to September and more than 700 have been observed at one time in the immediate area of the pipe-line trench.	X
3	The range of the beluga population that uses the Mackenzie River estuary and the significance of the estuary relative to other portions of the beluga range are not known. However, the area disturbed by this dredging project would likely be a very small portion of the available beluga habitat.	X

TABLE E

AUDIT TRAIL

SHEET NO. 2 OF 5

NOTE NO.	CALCULATIONS, ASSUMPTIONS AND EVIDENCE	JUDGEMENT OF INFORMATION QUALITY Good Poor Unknown
4	The beluga population may be present in the general area from June to early September (approximately 12 weeks). Therefore, the period of overlap would be approximately 8 weeks or greater than 10 percent $\frac{8 \text{ wks.}}{12 \text{ wks.}} \times 100 = 75$ percent.	X
5	Almost complete lack of food in stomachs of beluga whales landed by Inuit (Fraker 1977) and lack of observations of feeding activity suggest limited to no potential habitat-related effects of the dredging project.	X
6	The physical presence of vessels in the area may affect whale movements between Kugmallit Bay and Niakunak Bay. Due to the numbers of whales present in the area and the concentrations of whales in some locations during their stay in the area, more than 10 percent of the population may be affected by the dredging operation and support activities.	X
12	Arctic cisco are tolerant of a wide range of salinites (Lawrence et al. 1984) and may be present in both nearshore and offshore locations during the dredging operation. It is likely that only a small portion of the Beaufort Sea population would actually encounter the dredging operation.	X
13	Arctic cisco are present off Richards Island throughout the period of the dredging project (Lawrence et al. 1984). Arctic cisco also overwinter in the bays and lagoons of Richards Island. The temporal overlap with the population would be greater than 10 percent. $\frac{3 \text{ months}}{12 \text{ months}} \times 100 = 25$ percent	X

TABLE E

AUDIT TRAIL

SHEET NO. 3 OF 5

NOTE NO.	CALCULATIONS, ASSUMPTIONS AND EVIDENCE	JUDGEMENT OF INFORMATION QUALITY Good Poor Unknown
14	Although the spatial extent of siltation and turbidity would be greater than that for entrainment, less than 10 percent of the regional population of Arctic cisco would be affected due to their wide distribution in the southern Beaufort Sea.	X
15	Siltation and turbidity disturbances due to the dredging operation would affect a very small portion of the available fish habitat. Effects on shallow fish habitats might be indistinguishable from the effects of natural physical forces. For these reasons the effects on habitat would be minimal and a detailed assessment was not completed.	X
16	Rainbow smelt were present off Richards Island in small numbers throughout the summer and slightly greater numbers were caught in August and September than in June and July (Lawrence et al. 1984). Because these fish are widely dispersed, the number encountering the dredging operation would likely be very small.	X
17	Rainbow smelt spawn and overwinter in river systems (Lawrence et al. 1984); and occupy coastal Beaufort Sea habitats during spring, summer and fall. The temporal overlap would be approximately 75 percent.	

TABLE E

AUDIT TRAIL

SHEET NO. 4 OF 5

NOTE NO.	CALCULATIONS, ASSUMPTIONS AND EVIDENCE	JUDGEMENT OF INFORMATION QUALITY Good	Poor	Unknown
18	Broad whitefish are relatively intolerant of high salinites and use only nearshore low salinity areas along the coastline of Richards Island. Very low numbers of these fish would be expected to occur in waters greater than 3 m deep where the suction dredges would be operating. Consequently, both the temporal and spatial overlap of dredging with broad whitefish would be insignificant.	X		
19	While there is no direct information that the reproduction or survival of beluga whales would be affected due to disturbance from the dredging project, data for other populations indicate that stress can adversely affect reproduction. The greatest concern is for immature whales and neonates that might be prevented from entering warmer estuary waters; this could lead to overall reductions in growth or health.		X	
20	Although the environmental significance of dredging effects on beluga habitat is judged to be Class 4, the overall significance of this particular area for the beluga is not known. The potential effects of excluding the whales from the area could be highly significant.		X	
22	Alteration of bottom contours will occur in the area of the activities. It is expected that natural forces in this highly dynamic area would rapidly modify dredge-created bottom changes to the extent that they would be indistinguishable from natural conditions. The environmental significance of this disturbance was not assessed.	X		
23	Dredge-created noise has not been reported to adversely affect fish.	X		

TABLE E

AUDIT TRAIL

SHEET NO. 5 OF 5

NOTE NO.	CALCULATIONS, ASSUMPTIONS AND EVIDENCE	JUDGEMENT OF INFORMATION QUALITY Good Poor Unknown
24	The physical presence of dredges would be unlikely to adversely affect fish.	X
25	Other industrial activities in the region and the native whale hunt may also disturb belugas in the estuary.	X

TABLE F

RESPONSE TO ENVIRONMENTAL SIGNIFICANCE QUESTIONS

PROJECT: NIPTERK TO RICHARDS ISLAND PIPELINE TRENCH

SHEET NO. 1 of 1

VEC	POP. OR HAB. (Specify)	PROJECT DISTURBANCE	RESPONSE TO ENVIRONMENTAL SIGNIFICANCE QUESTIONS						ENVIRON. SIGNIFIC. CLASS	AT
			1	2	3	4	5	6		
Beluga	POP	Noise	>10	YES		YES	YES	LT	Class 2	19
Beluga	HAB	Noise	<10	YES	<10	NO			Class 4	20
Beluga	POP	Physical Presence	>10	YES	>10	YES	YES	ST	Class 3	
Beluga	HAB	Physical Presence	<10	YES	<10	NO			Class 4	20
Arctic Cisco	POP	Entrainment	<10	No					Class 4	
Arctic Cisco	POP	Turbidity/ Suspended Sediments	<10	No					Class 4	
Rainbow Smelt	POP	Turbidity/ Suspended Sediments	<10	No					Class 4	
Rainbow Smelt	POP	Entrainment	<10	No					Class 4	
Broad Whitefish	POP	Entrainment	<10	No					Class 4	
Broad Whitefish	POP	Turbidity/ Suspended Sediments	<10	No					Class 4	

AT = Audit Trail Cross-Reference (Table E)

TABLE G

ENVIRONMENTAL SIGNIFICANCE SUMMARY

PROJECT: NIPTERK RICHARDS ISLAND PIPELINE TRENCH

SHEET NO. 1 OF 1

VEC	PROJECT DISTURBANCE	ENVIRONMENTAL SIGNIFICANCE CLASS		
		POPULATION	HABITAT	AT
Beluga	Noise	Class 2+	Class 4+	25
Beluga	Physical Presence	Class 3+	Class 4+	25
Arctic Cisco	Entrainment	Class 4	-	
Arctic Cisco	Turbidity/Suspended Sediments	Class 4	-	
Rainbow Smelt	Entrainment	Class 4	-	
Rainbow Smelt	Turbidity/Suspended Sediments	Class 4	-	
Broad Whitefish	Entrainment	Class 4	-	
Broad Whitefish	Turbidity/Suspended Sediments	Class 4	-	

\+ - denotes potential for cumulative effects due to other activities in the region.

AT - Audit Trail Cross-Reference (Table E).

TABLE H

REFERENCES

PROJECT: NIPTERK RICHARDS ISLAND PIPELINE TRENCH

SHEET NO. 1 of 1

Department of Indian Affairs and Northern Development and Environment Canada. 1984. Beaufort environmental monitoring project. Unpublished report prepared by LGL Ltd., ESL Environmental Sciences Ltd. and ESSA Environmental and Social Systems Analysts Ltd. 292 pp.

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SUMMARY

NIPTERK TO RICHARDS ISLAND PIPELINE TRENCH

The most significant environmental concern associated with the dredging activity would be the potential effects of noise and the physical presence of the dredges and support vessels on beluga whales. The environmental significance of these possible effects was judged to be Class 2 and 3, respectively. However, there was no direct evidence that the reproduction or survival of beluga whales would be affected due to disturbance from dredging. Marine vessel activities have been shown to disturb whales and cause short-term avoidance responses by some individuals, although the potential for these effects to result in a long-term impact on survival or reproduction, or to cause long-term changes in abundance or distribution of whales in the habitats affected by dredging remains unknown (DIAND and Environment Canada 1984). Although the assessors acknowledge this uncertainty with respect to the environmental significance rankings, mitigative measures were considered necessary due to the social importance of beluga whales in this region.

Two potential mitigative measures were recommended: (1) a delay in the start of dredging to August 1, when most of the whales will have left the nearshore area, or (2) employment of a monitor on board the vessels and cessation of operations if whales are near the activity.

The adoption of an August 1 start date as a mitigative measure to reduce possible interactions with whales would reduce the proportion of the beluga population vulnerable to the effects of noise. However, during some years, ice conditions could restrict the available habitat for the whales, and more whales may be concentrated in the area of the dredging project. Therefore, it was concluded that more than 10 percent of the population might still be within the zone of influence of the project. The August 1 start date for the dredging operation could reduce the temporal overlap. However, it would still be greater than 10 percent (i.e., 5 weeks/12 weeks x 100 = 42 percent).

The presence of a monitor during the dredging operation and the curtailment of noise-producing activities when whales were observed in the area would reduce the portion of the population affected. However, the monitor would be unable to reduce the potential disturbance to whales due to the actual physical presence of dredges and support vessels.

REFERENCES

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ACKNOWLEDGEMENTS

The contributions of Lois Harwood, formerly of ESL Environmental Sciences Limited, and Brian Smiley of the Institute of Ocean Sciences to the Method for Preliminary Assessment of Environmental Impact (Duval et al. 1984) upon which this Process is largely based are gratefully acknowledged. Mr. Smiley also kindly provided VEC criteria used in this report.

The first draft of this process was refined and finalized during a two-day workshop held in Vancouver and attended by both government and industry representatives (Appendix A). The authors are grateful for the expertise of the workshop participants and the energetic exchange of ideas during the workshop that greatly benefited the project and the final Assessment Process.

The hypothetical case study presented in Part 4 was completed at a workshop held at the Freshwater Institute, Winnipeg, December 12 and 13. Michael Lawrence coordinated the workshop and the Scientific Authority for this project, Glen Packman, provided the background information for the case studies. The workshop was attended by B. Bond, L. Lockhart, T. Strong, and B. Fallis of Fisheries and Oceans Canada and G. Packman. The cooperation and enthusiastic involvement of the Scientific Authority, Mr. Packman, and Fisheries and Oceans personnel who participated at the workshop are gratefully acknowledged. The report was typed by Maria Galan and Tammy Lehman of ESL Environmental Sciences Limited. Sharon Galenzoski of XY3 Graphics drafted the tables and figures.

APPENDIX I

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APPENDIX II

GLOSSARY OF TERMS

AGE STRUCTURE	The relative frequency of individuals in the population as a function of age (or fraction of the population falling in successive age classes).
BIRTH RATE	The number of births per a given number of individuals (usually 1000) in a specified district and in a specified period of time.
DEATH RATE	The number of organisms per thousand of population that die within a given time.
DENSITY	The number of specified individuals per definite unit of space (e.g. hectare, square kilometre, etc.).
DISPERSION	The spacing of members of a population in its habitat (e.g., random or uniform throughout, in groups, etc.).
GENERATION	The period of time between the birth of a parent and that of its offspring.
HABITAT	The region or environment where a plant or animal or a particular population is normally found.
IMPACT	A short- or long-term change caused by development activity that is directly or indirectly harmful to resident species or their habitat.
INDIVIDUAL	A single organism of a species.

POPULATION — A group of individuals of a species inhabiting the Beaufort Sea, or an isolated smaller area within the Beaufort Sea.

QUALITY — In Figure 2, Question 4 "quality" is intended to describe the increase in body burdens of contaminants in an organism due to bioaccumulation.

SIGNIFICANT — The importance of an effect defined in terms of its ecological, statistical and social consequences. Ecological significance is defined as an effect that can be detected at the individual level of biological heirarchy and is known or expected to be important at the population level in terms of survival or reproduction. Statistical significance is defined as a project-related change that can be detected from baseline conditions and normal variability by acceptable statistical procedures. Social significance is the judgement by the public of the acceptibility and desirability of the ecological effects in terms of their commercial, recreational or aesthetic importance. The implications of each of these concepts in the definition of significance are discussed in detail by Beanlands and Duinker (1983) and assessors should refer to this document for more background information regarding the definition of this term.

SPATIAL OVERLAP — The estimated percentage of a particular population or its habitat that is influenced by the project in any given year.

TEMPORAL OVERLAP — The duration of the disturbance divided by the population residence time that the disturbance occurs over multiplied by 100. Use the same period (days, weeks or months).

VALUED ECOSYSTEM COMPONENT (VEC)

A population that has social and economic significance and which, if affected by development, will be of concern to scientists, managers, and government regulators. The following criteria may be used to select VECs:

Rare and Endangered - Species with few individuals, either due to natural circumstances or human perturbations, and having a designated protected status.

Subsistence Use - Species that are harvested by indigenous people for their own consumption.

Commercial - Species that are harvested and marketed for economic profit.

Recreational/Aesthetic Value - Species that are harvested or observed for enjoyment by anyone

Scientific Interest - Species that are studied and examined by scientists for purposes of pure (speciation, behaviour, etc.) and applied research (pollution sentinel, medicine derivatives, etc.).

Trophic Importance - Species that are common important prey for (or predators on) other species within the marine foodweb.

International Value - A species that is covered by laws, treaties and other agreements concerning its joint management by bordering countries.

Vulnerability - Species that are likely to directly encounter dredging activities due to preferences in timing and location.

Sensitivity - Species that are likely to be harmed when encountering dredging activities, due to the behaviour, physiology, morphology, etc., of the plant or animal above criteria.

ZONE OF INFLUENCE The spatial extent within which the presence of the disturbance or pollutant can be detected by the population in question. Most often, the zone of influence is roughly calculated against the natural background condition (e.g., ambient noise levels or heavy metal concentrations). Zone of influence, together with the exposure time and numbers of animals involved, is used to determine spatial and temporal overlap.

APPENDIX III

SELECTED LITERATURE DISCUSSING THE ENVIRONMENTAL EFFECTS OF DREDGING

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Herbich, J.B. 1981a. Dredging equipment and the effects of dredging on the environment. In: Marine Environmental Pollution (Vol. 2). Dumping and Mining. R.A. Geyer (Ed) Elsevier. Amsterdam. pp. 227-240.

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APPENDIX IV

SUB-QUESTIONS AND CONSIDERATIONS FOR ASSESSMENT OF ENVIRONMENTAL SIGNIFICANCE

Please note: This list is incomplete and only indicates the type of detailed questions that should be evaluated during assessment of Environmental Significance.

QUESTION 1: WHAT PROPORTION (X) OF THE POPULATION OR HABITAT OVERLAPS WITH THE PROJECT DISTURBANCE (ANSWER FROM TABLE D)?

- What is the estimated percent of the regional VEC population which may be involved in a direct interaction with the project disturbance?

- What is the estimated percent of the species habitat that may be affected by the project disturbance?

QUESTION 2: WOULD TOTAL LOSS OF "X" BE OF CONCERN?

- The response to this question is largely based on professional judgement and the assessor's knowledge of the species.

QUESTION 3: WHAT PROPORATION "Y" OF THE POPULATION OR ITS HABITAT IS AFFECTED?

- The possible relationships between "Y" and "X" are: (1) $Y=X$, (2) $Y<X$, or (3) $Y>X$. The following sets of circumstances describe these potential relationships:

  (1) if $Y=X$, then all the proportion of the population or habitat that overlaps with the disturbance is affected;
  (2) if $Y<X$, then some proportion of the population or habitat that overlaps with the disturbance may be unaffected; and

(3) if Y>X, then the proportion of the population or habitat that overlaps with the disturbance is affected in such a way that effects become manifested in a larger proportion of the regional population (for example, if the habitat affected is critical to the successful reproduction of some portion the population).

QUESTION 4: IS THE EFFECT OF "Y" SIGNIFICANT TO THE SURVIVAL, REPRODUCTION, USE OR QUALITY OF THE POPULATION?

- Will the project cause direct mortality (immediate or delayed) of any age group?

- If mortality occurs, will it exceed natural mortality rates in the population?

- What proportion of the population would be directly lost through mortality, and what proportion would be affected in a sublethal manner?

- What natural factors influence survival in the population?

- What type of habitat will be affected (i.e., reproductive, rearing (feeding), overwintering, staging or holding, migration)?

- Will growth or health be affected through physiological stress, loss of food sources, loss of critical habitat or other factors?

- What period in the annual life cyle would be affected by the project?

- Is the period of project interaction critical to the survival of the population?

- Could the dredging project result in non-lethal effects (e.g., changes in food sources, migration patterns, behaviour, and distribution) that would influence survival and/or normal patterns of reproduction?

- Is the species rare and/or endangered, and if so, has this classification been assigned because of a low reproductive potential?

- Could non-lethal effects such as accumulation of contaminants or impaired respiration rates affect the population?

- Could concentrations of accumulated contaminants result in other non-lethal effects such as histological, genetic or physiologic changes?

- Could body burdens of contaminants cause tainting or otherwise affect the quality of an organism used as a food source?

- Does the species store, metabolize or excrete the contaminant?

- Are the effects of products of the metabolism of the contaminant known to be harmful?

QUESTIONS 5 AND 6: WILL RECOVERY OF THE POPULATION OCCUR ?
HOW LONG IS RECOVERY EXPECTED TO REQUIRE ?

- What is the reproductive potential of the species (e.g., reproductive rates, generation time, natural birth, and death rates) ?

- Are the population dynamics of the species characterized by either pronounced or rapid changes (cycles) in abundance ?

- Is the same proportion of the regional population affected during each year of the project ?

- Will individuals affected by the project in one year avoid the Project Zone of Influence in subsequent years ?

- Are the food and habitat requirements of the species relatively rigid, or is the species considered opportunistic ?

- Will the project result in differential effects on specific age classes or either sex ?

- Are changes in the genotype of the population possible through mutations ?

- Will the project result in behavioural changes in subsequent generations that could then affect survival or reproduction ?

- Will the project increase the susceptibility of the regional population to diseases and parasites ?

- What other impact sources may be simultaneously affecting the species population?

- What is the potential for recovery through immigration?

  - is the species likely to immigrate ?
  - are there individuals in adjacent areas that could immigrate?
  - is there adequate food and habitat available for immigrants?

- Can the species compensate for population losses by increasing production, and if so, is there sufficient food and habitat for it to do so ?

- Is there sufficient production from elsewhere in the region to support immigration of individuals into the affected area?

- Could the affected species be replaced by another species in the same ecosystem such that competition would impede its recovery?

- Is the species harvested in this or other regions to the extent that harvesting could impede recovery?

- Could rates of recovery of the affected population be artificially increased through habitat enhancement or transplantation of individuals from unaffected areas?